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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

OAST SPACE THEME WORKSHOP

VOLUME III

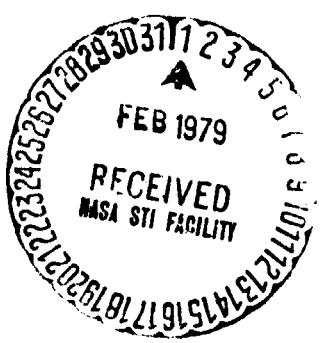
WORKING GROUP SUMMARY

I. NAVIGATION, GUIDANCE, CONTROL (E-1)

A. Statement

B. Technology Needs (Form I)

C. Priority Assessment (Form II)



Held at the
Langley Research Center
April 26-30, 1976

Sponsored by NASA-Code RX

Foreword

The attached material represents the working papers from the OAST Space Theme Workshop held at the Langley Research Center, April 26-30, 1976, and contains a quick-look analysis of the proceedings. The material is unedited and intended for further use by the participants of the workshop and the planning elements of NASA concerned with space mission research and technology. It should be understood that the data do not represent official plans or positions but are part of the process of evolving such plans and positions.

Nearly 100 of the Agency's top technologists and scientists joined with another 35 theme specialists to produce this working document - a document that provides a technical foundation, including research and technology base candidates, for each of the six space themes.

The material in this report is considered essential to the development of Center initiatives in support of these themes. Copies of the report will be made available to the Center Management Board and the individuals at the Centers responsible for the FY'78 program planning cycle. The timing of this planning activity has caused us to distribute this document in this unedited form. Thus, it possibly contains errors, hopefully, more of a typographical rather than a technological nature. Nonetheless, the information contained is of a high professional level, reflecting the efforts of the workshop participants and will be invaluable to the planning and successful execution of the Agency's near- and far-term advanced technology program.

Stanley R. Sadin
OAST Space Theme Workshop
Chairman
NASA Headquarters
Study, Analysis, & Planning Office
Office of Aeronautics and
Space Technology

NAVIGATION, GUIDANCE, AND CONTROL

The results of the Workshop indicate that the themes have many common navigation guidance and control needs. All the earth orbit themes have a strong requirement for attitude, figure and stabilization control of large space structures, a requirement not currently being supported. All but the space transportation theme have need for precision pointing of spacecraft and instruments. In addition all the themes have requirements for increasing autonomous operations for such activities as spacecraft and experiment operations, onboard mission modification, rendezvous and docking, spacecraft assembly and maintenance, navigation and guidance, and self-checkout, test and repair.

It is clear that major new efforts are required to conceptualize new approaches to large space antennas and arrays that are lightweight, ready deployable and capable of precise attitude and figure control. Conventional approaches offer little hope of meeting these requirements. Similarly, it is also apparent that the time has come to move from conceptual machine intelligence to applications. Increasing autonomy in the space program has great potential for reducing costs and ground support requirements and increasing mission return.

Some of the Functions That Can Benefit From Increasing Automation or Autonomous Operations

- Orbit Changes
- Experiment Pointing
- Experiment Control
- Manipulation
- Data Evaluation and Reduction
- Telemetry Control
- Housekeeping Functions
- Locomotion Control
- Collision Avoidance
- Navigation and Guidance
- Attitude and Figure Control
- Payload Servicing, Repair or Retrieval
- Assembly of Large Structures
- Checkout/Status
- Mission Planning (Preflight and Real Time)
- Failure Detection and Reconfiguration
- Control of Consumables
- Rendezvous and Docking
- Entry and Landing

N, G & C NEW INITIATIVES

1. Advanced G&C components for S.T.S. including: CCD STAR TRACKERS, ELECTRO-MECHANICAL ACTUATORS & SENSORS FOR AUTO-RENDEZVOUS and Docking.

2. Science Platform Precision Pointing and Tracking System for non-inertial targets.

3. Experiment Isolation and Pointing System.

4. A dexterous manipulator for remote man-controlled assembly and servicing.

5. Control systems for Altitude and Figure Control of Large Deformable Structures.

6. Systems and Components for Autonomous Rendezvous and Docking.

7. Low Thrust Guidance and Navigation Program.

8. Space Teleoperator Experiment (STEV) Free Flying Modular Instrument Pointing Technology Laboratory.

9. Design Technology for Digital Control Systems.

10. Sensor development for inertial pointing.

11. Extended body Tracker Technology.

12. Correlation Landmark Tracker Technology.

13. Autonomous Guidance and Navigation Flight/Ground Demonstration.

14. Autonomous Mission Operations Sequencing & Control.

15. Dynamics and Control of Unmanned Planetary Entry and Landing Vehicles.

NAVIGATION, GUIDANCE AND CONTROL

KEY ISSUES

△ LARGE STRUCTURE CONTROL

- INTEGRATED STRUCTURE/CONTROL SOLUTIONS
- SENSOR/ACTUATOR/ANALYSIS CAPABILITIES

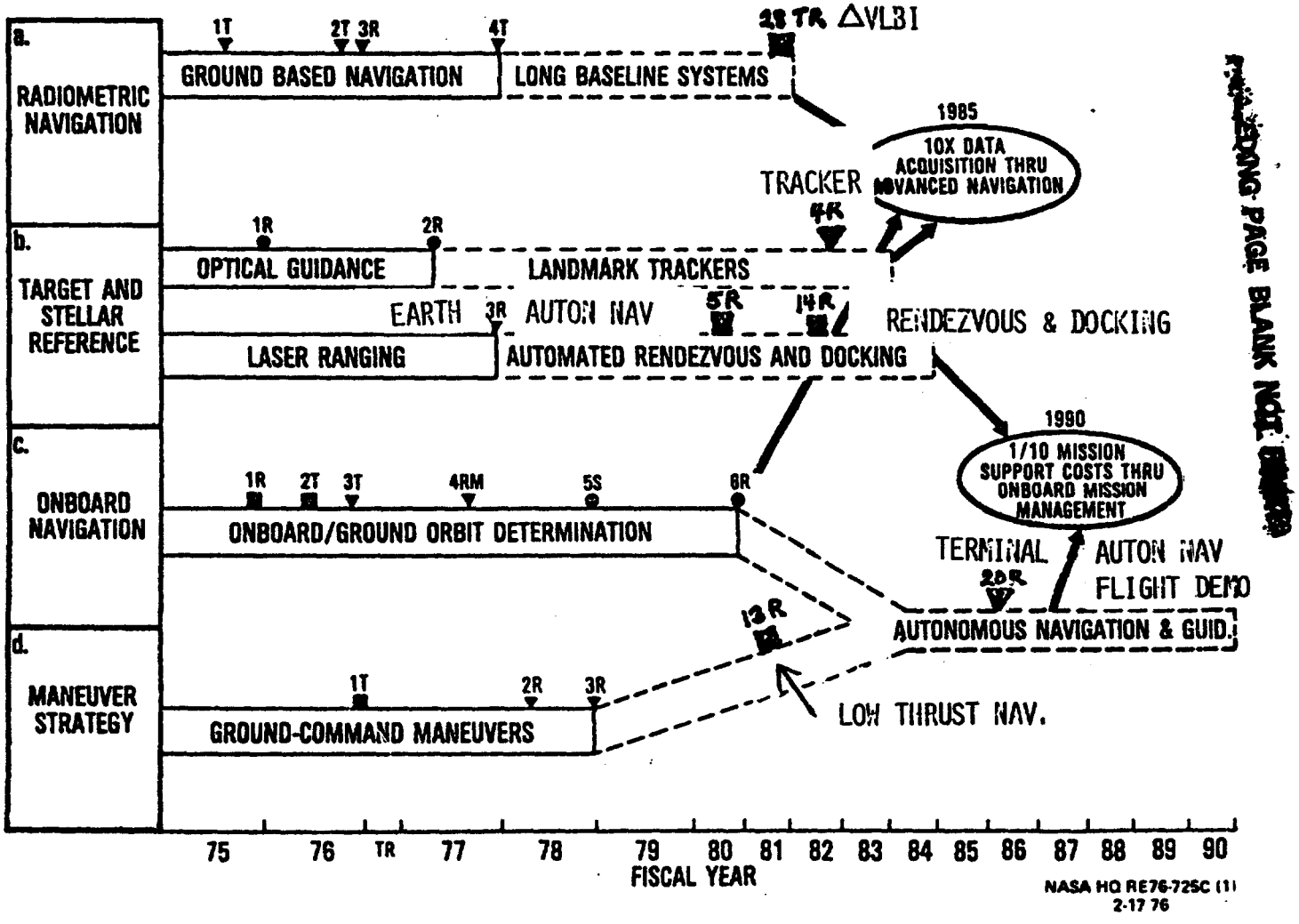
△ INSTRUMENT POINTING

- SENSORS/TRACKERS/MOUNTS
- ANALYSIS AND SIMULATION CAPABILITIES
- TRACKING SYSTEMS

△ AUTONOMOUS SYSTEMS

- NAVIGATION AND GUIDANCE
- ROBOTICS
- RENDEZVOUS AND DOCKING
- STATION KEEPING

1. NAVIGATION AND GUIDANCE



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2-17 76

RESOURCE SUMMARY

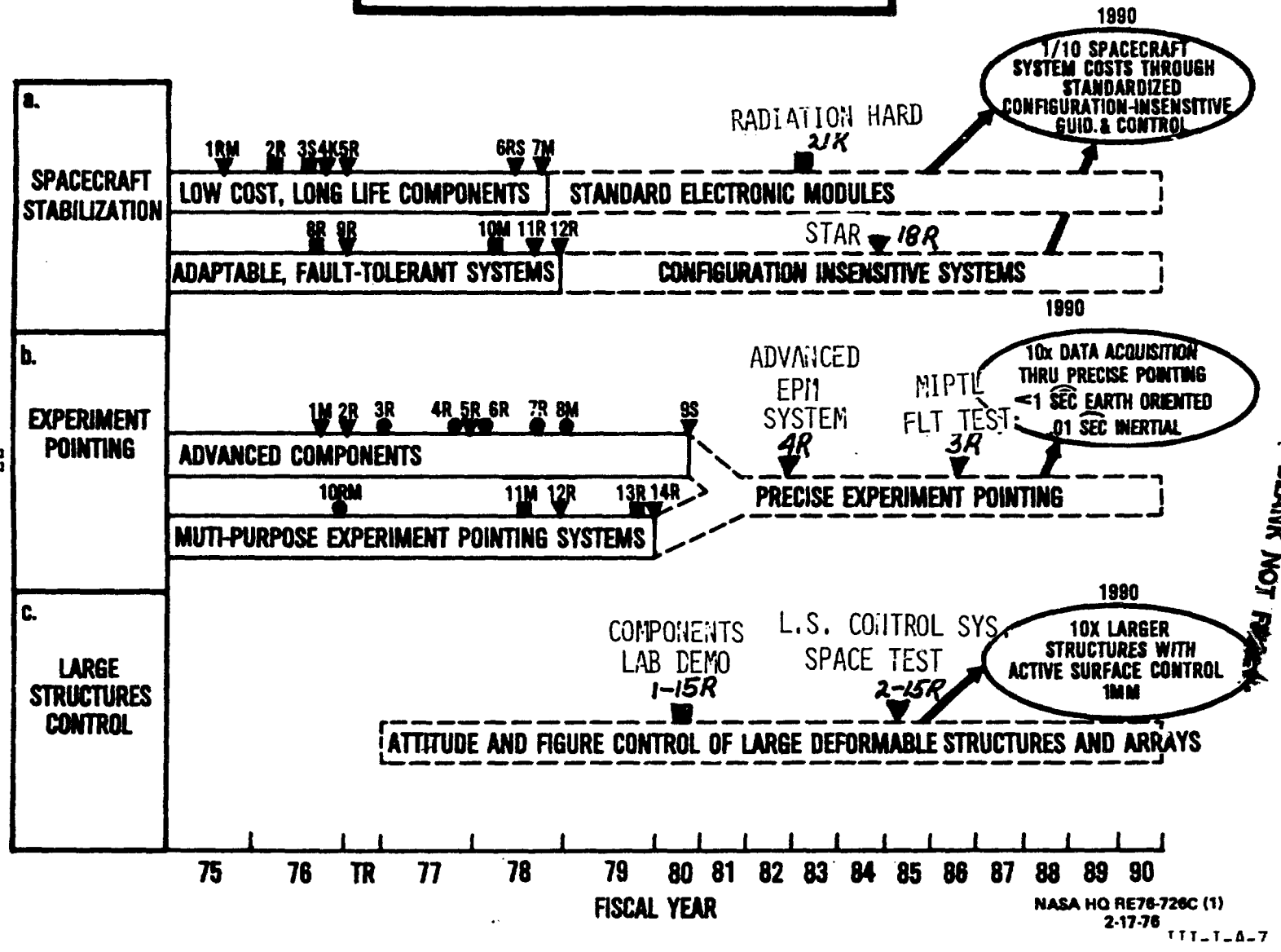
NAVIGATION, GUIDANCE, AND CONTROL

I. NAVIGATION AND GUIDANCE DISCIPLINE CATEGORY

RESOURCES \ FY		76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
MANPOWER	INHOUSE			22	30	35	17.7	14	10								128.7
MANPOWER	CONTRACT																
FUNDING, $M	INHOUSE			3.9	6.3	6.5	4.7	4.0	3.8								29.2
FUNDING, $M	CONTRACT																

NOTE: MANPOWER AND $ ARE ADDITIVE, NOT REDUNDANT.

2. POINTING AND CONTROL



77

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2-17-76

RESOURCE SUMMARY

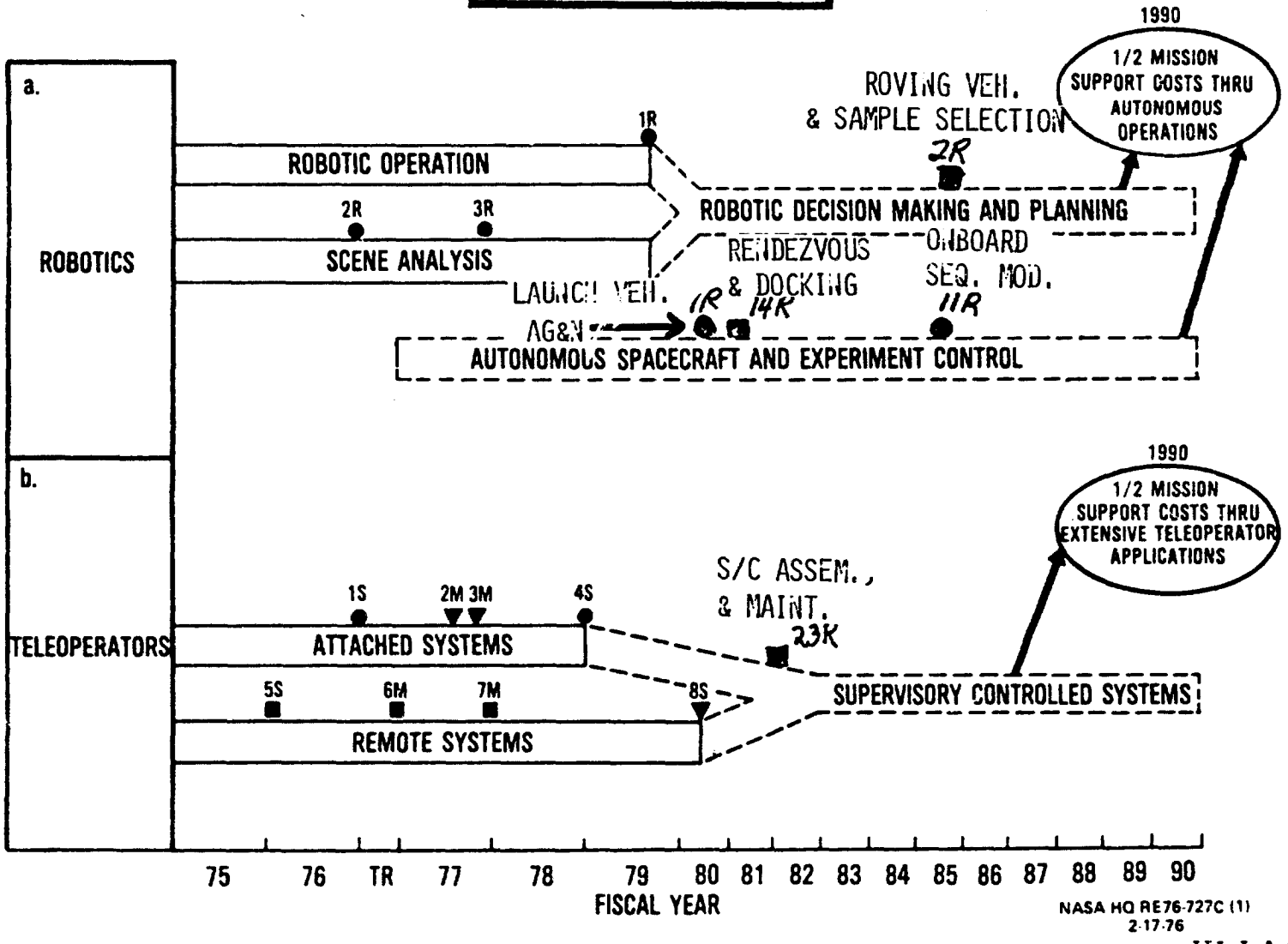
NAVIGATION, GUIDANCE, AND CONTROL

II. POINTING AND CONTROL DISCIPLINE CATEGORY

RESOURCES \ FY		76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
MANPOWER	INHOUSE			60	80	84	73	61	60	55	35	30					538
	CONTRACT																
FUNDING, $M	INHOUSE			5.9	8.6	10.3	9.3	8.6	8.2	7.7	6.7	3.0					68.3
	CONTRACT																

NOTE: MANPOWER AND $ ARE ADDITIVE, NOT REDUNDANT.

3. AUTOMATION



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RESOURCE SUMMARY

NAVIGATION, GUIDANCE, AND CONTROL

III. AUTOMATION DISCIPLINE CATEGORY

RESOURCES \ FY		76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
MANPOWER	INHOUSE			34	34	33	32	30	30	2.4	0						195.4
	CONTRACT																
FUNDING, $M	INHOUSE			4.1	4.0	4.0	3.9	4.1	4.1	2.4	2						28.9
	CONTRACT																

NOTE: MANPOWER AND $ ARE ADDITIVE, NOT REDUNDANT.

RESOURCE SUMMARY

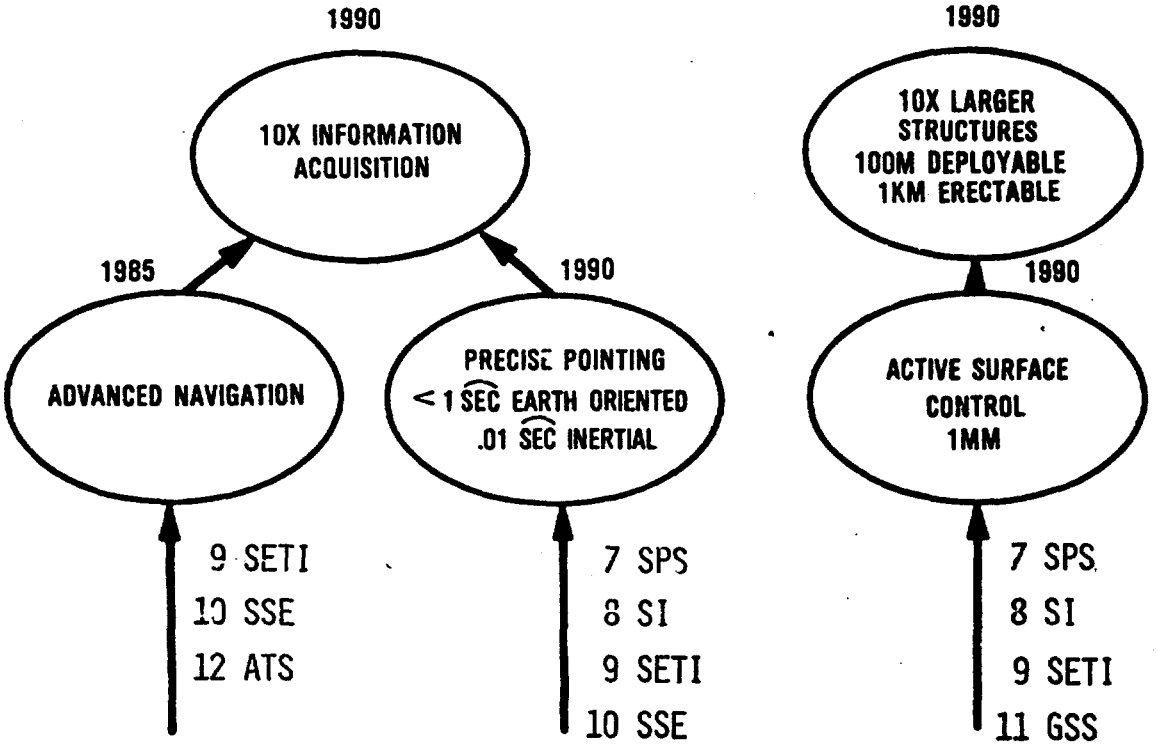
NAVIGATION, GUIDANCE, AND CONTROL

TOTALS

RESOURCES \ FY		76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	TOTAL
MANPOWER	INHOUSE			116	144	152	123	105	100	67.4	35						832.1
	CONTRACT																
FUNDING, $M	INHOUSE			4.1	18.9	20.8	17.9	16.7	16.1	8.7							113.3
	CONTRACT																

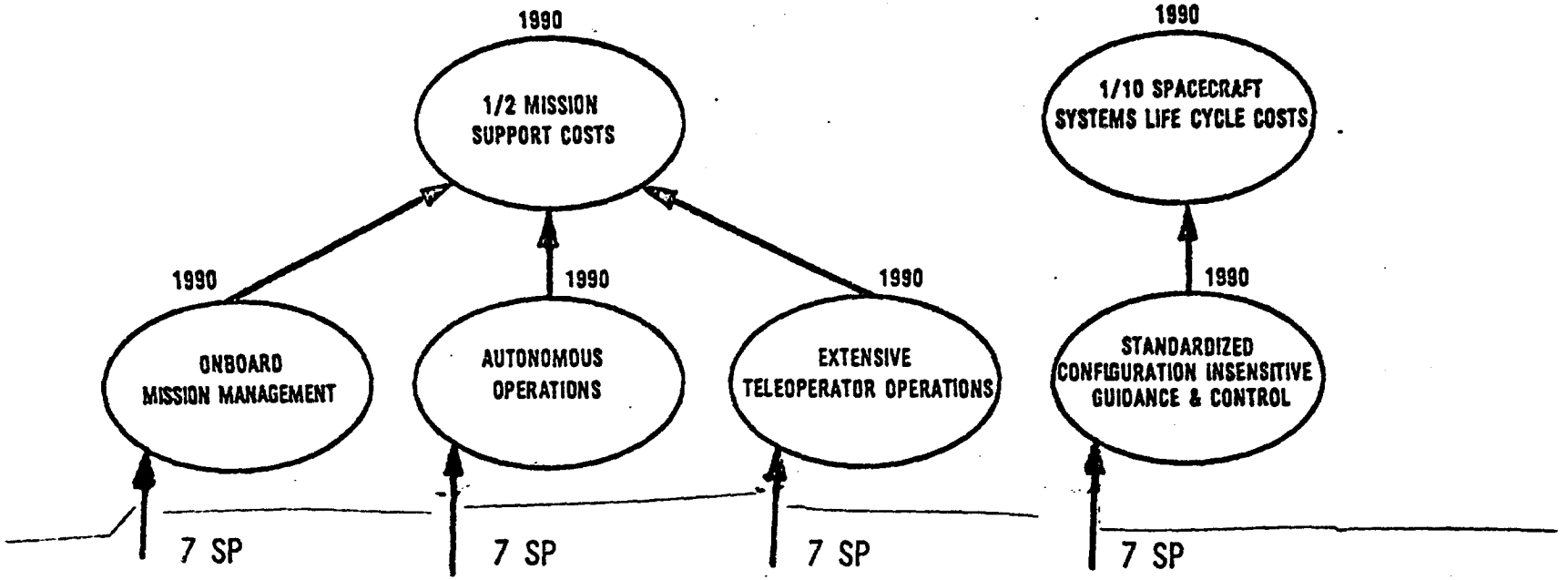
NOTE: MANPOWER AND $ ARE ADDITIVE, NOT REDUNDANT.

NAVIGATION, GUIDANCE AND CONTROL



97

NAVIGATION, GUIDANCE AND CONTROL



SPACE TECHNOLOGY NEED **FORM NO. 1**

PAGE 1 OF _____

1. TITLE AUTONOMOUS GUIDANCE AND CONTROL OF LAUNCH VEHICLES

NO. 12 / E1 / 1
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE
TO MINIMIZE OR ELIMINATE THE NECESSITY FOR GROUND SUPPORT (TRACKING, COMMUNICATION) FROM LIFT-OFF TO ORBIT INSERTION

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [7] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY DATE: 1985

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [X] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [ ]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [ ] _____ (Check one or more)

f) R&T BASE CANDIDATE _____

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY DATA PROCESSING HARDWARE, GUIDANCE AND CONTROL SOFTWARE

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

- PRECISION NAVIGATION SYSTEMS WITH PRECISION GROUND ALIGNMENT CAPABILITY
- RAPID ONBOARD ORBIT VERIFICATION TECHNIQUES

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 2 OF ____

TITLE AUTONOMOUS GUIDANCE AND CONTROL OF LAUNCH VEHICLES

NO. 12 / F1 / 1 (THEME / W.G.7 / TASK)

DATE 4/28/76

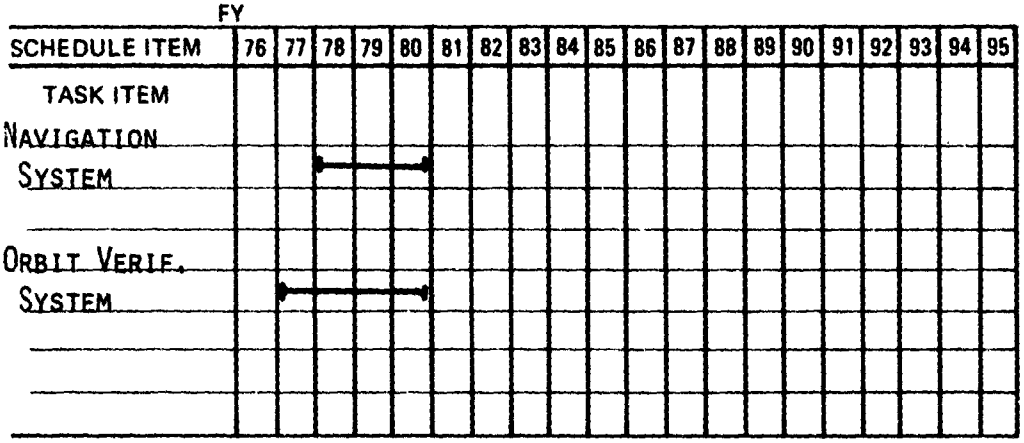
6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

THE DEVELOPMENT OF PRECISION NAVIGATION SYSTEM AND ALIGNMENT PROCEDURES AND EQUIPMENT TO PROVIDE ACCURATE INFORMATION FOR PATH CONTROL. THE DEVELOPMENT OF ONBOARD SYSTEMS/TECHNIQUES FOR RAPID ORBIT VERIFICATION.

7. ALTERNATIVE APPROACHES/OPTIONS CONTINUE TO USE GROUND TRACKING FOR TRAJECTORY STATUS, RANGE SAFETY, AND ORBIT VERIFICATION

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y) INHOUSE		1	2	2	2															
CONTRACT		1	3	7	5															
FUNDING (10^6 $) INHOUSE		.05	.1	.1	.1															
CONTRACT		.5	1.0	1.5	1.0															

SPACE TECHNOLOGY NEED **FORM NO. 1**

PAGE 1 OF _____

1. TITLE Roving Vehicles, Sample Selection/ Acquisition

NO. 1.8.10/E-1/2
THEME / W.G. / TASK

DATE 4 /26 /76

2. OBJECTIVE
To develop roving vehicles for support of sample analysis and/or sample return missions and for general survey. Also rovers for maintenance and service of lunar or other bases.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [7] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY DATE: 1990

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [X] Computer simulation (Check one or more)

f) R&T BASE CANDIDATE Yes 506-19-32 960K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Development of advanced self adaptive software

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED
Eye/hand coordination, obstacle avoidance/navigation, hazard avoidance, development of dexterous manipulator and sample acquisition, pattern recognition/screen analysis, large scale associative memories, multi-channel micro processor arrays, development of real time dynamic modeling techniques.

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED **FORM NO. 1**

PAGE 2 OF ____

TITLE Roving Vehicles, Sample Selection/Acquisition NO. 1.8.10/E1/2

THEME / W.G. / TASK

DATE 4 / 26 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Expand existing development programs to include sample selection/ acquisition capability extend software development activity.

7. ALTERNATIVE APPROACHES/OPTIONS Astronauts

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Robotics/Teleoperator Development at JPL

RTOPS 186-68-55, 506-19-32

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Hardware/Software Development	←	—	—	—	→															
Field Tests				←	—	—	—	—	—	→										
Design Refinement							←	—	—	→										
MANPOWER (M-Y) INHOUSE	18	18	40	40	40	40	40	40	40	40										
CONTRACT																				
FUNDING (10^6 $) INHOUSE	.93	.93	2	2	2	2	2	2	2	2										
CONTRACT																				

SPACE TECHNOLOGY NEED FORM NO. 1

PAGE 1 OF _____

1. TITLE Precision Pointing of Spacecraft and Instruments at Inertially-Fixed Targets

NO. 1,7,8,9,12 / E1 / 3 (THEME / W.G. / TASK)

DATE 4 / 28 / 76

2. OBJECTIVE

A comprehensive program to provide systems to precisely point spacecraft or scientific instruments at inertially-fixed targets.

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [6] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1990]

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X] GRD TEST [X] AIR CRAFT TEST [X] SPACE FLIGHT TEST [X] OTHER (Specify) [X] Computer simulation (Check one or more)

f) R&T BASE CANDIDATE 506-19-13 150K, 506-19-15 125K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

Digital control system design techniques, microprocessors, CCD arrays.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Implementation of modern control theory algorithms, including:

Kalman filters and state estimators for multi-input and multi-output systems

Adaptive and learning control laws

Advanced mount technology

Computer-aided design and simulation techniques

Advanced sensor development, including:

CCD focal plane sensors

~~CCD acquisition and star trackers~~

Gyros - laser, tuned-rotor, magnetically supported

Advanced actuator technology

~~Control of flexible bodies~~ - control/body interaction

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED **FORM NO. 1**

TITLE Precision Pointing of Spacecraft and Instruments at Inertially-Fixed Targets

NO. 1,7,8,9,12 / E1 / 3 (THEME / W.G. / TASK)

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

A broad based in-house program of analysis, simulation and hardware, supplemented with contract activity as required. Laboratory demonstration, aircraft testing and space flight testing should all be employed as new elements become available.

7. ALTERNATIVE APPROACHES/OPTIONS

No alternatives exist because current technologies will not meet all the requirements for fixed target programs.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

RTOP 506-19-13 for advanced S/C and control systems

M/PTL/EIPS Study for Space Lab Test Capability 977-10-20 Spacelab IPS Dynamics

RTOP 506-19-15 Video Inertial Pointing

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Adv Cont. Tech.	—	—	—	—	—	—	—	—	—	—	—									
Adv Sensors	—	—	—	—	—	—	—	—	—	—	—									
Adv Actuators	—	—	—	—	—	—	—	—	—	—	—									
Flex Veh. Control	—	—	—	—	—	—	—	—	—	—	—									
Sys. Sim.			—	—	—	—	—	—	—	—	—									
Des. Tool Dev.	—	—	—	—	—	—	—	—	—	—	—									
Integ. & Demo.				—	—	—	—	—	—	—	—									
MANPOWER (M-Y) INHOUSE			30	30	30	30	30	30	30	30	30									
MANPOWER (M-Y) CONTRACT																				
FUNDING (10^6 $) INHOUSE			3	3	3	3	3	3	3	3	3									
FUNDING (10^6 $) CONTRACT																				

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED **FORM NO. 1**

PAGE 1 OF _____

1. TITLE Precision Pointing and Tracking Systems for Non-Inertial Targets

NO1.7.10.11 / B1 / 4
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

A comprehensive program to provide systems capable of precisely ~~pointing~~ and tracking at high rates (.1°/sec.) non-inertial targets. This ~~technology is applicable to planetary and earth pointing~~ spacecraft and platforms.

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [6] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1990]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [X] SPACE FLIGHT TEST [X]
OTHER (Specify) [X] Computer simulation (Check one or more)

f) R&T BASE CANDIDATE 506-19-13,14,15 300K, 150K, 100K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

Improved digital system design techniques, CCD array technology, microprocessor technology.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Advanced trackers, including:
- Advanced CCD technology
- ~~Target body tracking algorithms~~
- Landmark tracking algorithms

Precision actuators, including:
- ~~Magnetic suspension~~
- Magnetic bearing reaction wheels

Flexible vehicle configuration control - including modeling of flexible ~~vehicle dynamics in control laws~~

Advanced onboard processors - microcomputers

High precision real-time orbit determination using the global positioning ~~system~~

Radiation of sensors and electronics.

SPACE TECHNOLOGY NEED FORM NO. 1
PAGE 2 OF ____

TITLE Precision Pointing and Tracking Systems for Non-Inertial Targets

NO. 1,7,10,11/EI-4
THEME / W.G. / TASK

DATE 04 / 28 / 76 -2200

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

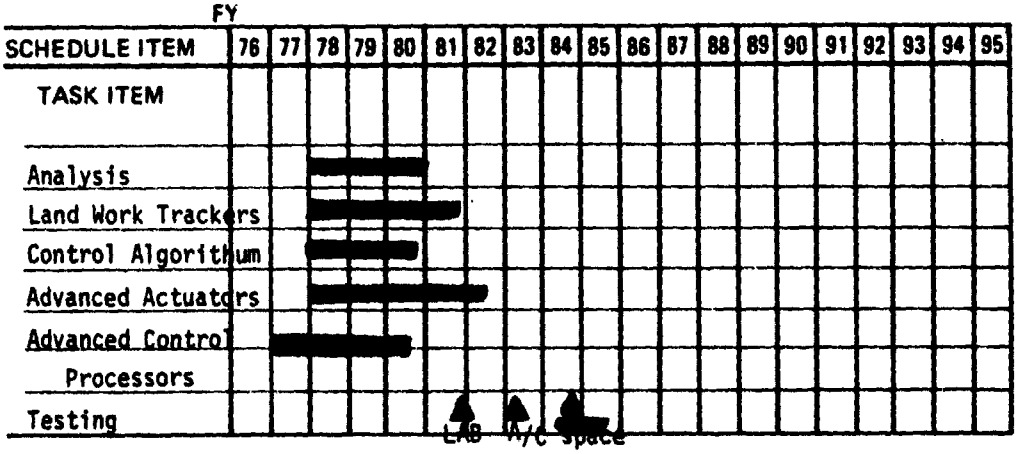
A Broad based in-house program for technology supplemented with contracts as required for hardware development. Hardware demonstrations supported by system analysis and simulation leading to aircraft and spaceflight testing as appropriate.

7. ALTERNATIVE APPROACHES/OPTIONS Less total data and more ground processing of data obtained

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

506-19-14 RTOP Provides basic CCD Sensor Technology and momentum wheel technology. 506-19-13 provides magnetic suspension technology. MIPTL Study for Flight Test

9. TECHNOLOGY SCHEDULES



LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
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6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED — **FORM NO. 1** — PAGE 1 OF _____

1. TITLE Autonomous Navigation - Earth Orbiters — NO. 7.11.9.12/E-1/5 (THEME / W.G. / TASK)

DATE 4 / 27 / 76

2. OBJECTIVE To reduce mission operations costs by utilizing on-board systems to perform mission planning, orbit station keeping, altitude contro

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [7] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1985]

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [ ] GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X] OTHER (Specify) [ ] _____ (Check one or more)

f) R&T BASE CANDIDATE _____

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY On-board navigation sensors, GPS receivers, advanced low thrust propulsion

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

- On-board orbit determination utilizing either on-board navigation sensors or external navigation data services (GPS)
- Combined orbit/altitude/sensor control laws and mission objective models
- Advanced user/and altitude communication systems and on-board command management

SPACE TECHNOLOGY NEED **FORM NO. 1**

PAGE 2 OF ____

TITLE Autonomous Navigation - Earth Orbiters NO. 7,11,12/E1/5

THEME / W.G. / TASK

DATE 4 /27 /76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Development of combined altitude/orbit/sensor control laws and actuators.
Development of mission models and command management systems utilizing minimal ground support operations.

7. ALTERNATIVE APPROACHES/OPTIONS High cost mission operations

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

310-10-22, 23 RTOP

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
On Board/Ground Systems Develop.	Δ				▼															
MANPOWER (M-Y) INHOUSE	2	2	2	2	2															
CONTRACT																				
FUNDING (10^6 $) INHOUSE																				
CONTRACT	.2	.3	.5	.5	.5															

SPACE TECHNOLOGY NEED FORM NO. 1

PAGE 1 OF _____

1. TITLE Dynamics and Control of Unmanned Entry and Landing

NO. 10,12 E1 6 (THEME / W.G. / TASK)

DATE 4/27/76

2. OBJECTIVE

To provide technology readiness for planetary atmospheric probes, and selective lander spacecraft, and advanced STS vehicles.

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [7] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1988]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [XX] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [XX] RESEARCH [ ]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [ ] _____ (Check one or more)

f) R&T BASE CANDIDATE _____

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Heat shield technology, probe structures, planetary atmospheres, in-situ control sensors.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Vehicle and path control concepts and hardware mechanizations to utilize aerodynamic control in planetary atmospheres (with large unknowns if vehicle is for other than earth).

Navigation and guidance concepts and mechanizations to autonomously land at selected sites with minimum landing dispersions.

Navigation and guidance concepts and mechanizations for automatic earth landing.

LEVEL OF STATE OF ART

1 BASIC PHENOMENA OBSERVED AND REPORTED
2 THEORY FORMULATED TO DESCRIBE PHENOMENA
3 THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4 PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5 COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6 MODEL TESTED IN AIRCRAFT ENVIRONMENT
7 MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED FORM NO. 1

PAGE 2 OF

TITLE Dynamics and Control of Unmanned Entry and Landing

NO. 10,12 E1 6 (THEME / W.G. / TASK)

DATE 4 / 27 / 75

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

For given entry configurations, the development of control algorithms which are insensitive to atmospheric dispersions and/or use in-situ sensing for adaptive path control. The development of external sensing devices (imaging systems) and/or homing devices for terminal navigation and path control.

7. ALTERNATIVE APPROACHES/OPTIONS Continue to accept large landing/impact dispersions. Develop guided terminal descent system.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

ARC sponsored planetary workshops/planetary probe development. LaRC/JPL Viking Program. Shuttle automatic landing system

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Lifting Body Control		———	———	———																
Terminal Nav. Systems				———	———	———														
Flt. Test Concept & Test				.			———	———												
MANPOWER (M-Y) INHOUSE		2	3	5	5	7	7	7												
CONTRACT		5	5	7	10	7	3	3												
FUNDING (10^6 $) INHOUSE		.05	.05	.1	.1	.05	.05	.05												
CONTRACT		.2	.2	.7	.7	.8	.5	.3												

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED — **FORM NO. I**

PAGE 1 OF _____

1. TITLE Automatic Stationkeeping — NO. 7, 8, 10, 9/E1/7 (THEME / W.G. / TASK)

DATE 4 / 26 / 76

2. OBJECTIVE

To demonstrate the ability to precisely stationkeep (six states) multiple non-physically coupled space structures relative to each other or earth references

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [2] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1988]

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [ ] MEDIUM [x] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [x] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [x] RESEARCH [x] GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [x] OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE _____

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Orbital mechanics improvements, large structures stabilization and control.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Objective can be met through the development of sensors for attitude and position determination, stationkeeping strategies (positive control) for vehicles in different orbits, and control effectors compatible (will not interfere) with signals attempting to be detected.

SPACE TECHNOLOGY NEED FORM NO. 1

PAGE 2 OF ____

TITLE Automatic Stationkeeping

NO. 7,8,9,10 / E-1 7
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Study alternative means for positioning measurement systems capable of defining the 6-dimensional relative antenna/feed coordinates to the submillimeter accuracy level. Create the conceptual ideas, design and fabricate the control system capable of maintaining the position to this same accuracy level for antennas and at relaxed levels, for other elements requiring relational station keeping.

7. ALTERNATIVE APPROACHES/OPTIONS A laser based system is the initially assumed measurement system of choice.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Alternative St. Measurem. Syst.			——	◁																
Con. Design, Fab. & Test				——	◁															
						——	◁													
Control System			↑																	
Design				——	◁															
Fabric & Test					——	——	◁													
Flight Test								◁												
MANPOWER (M-Y) INHOUSE			.2																	
CONTRACT																				
FUNDING (10^6 $) INHOUSE																				
CONTRACT			.2	.3	.5	1	2	2												

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF _____

1. TITLE CONTROL OF SPINNING SPACECRAFT (ARTIFICIAL GRAVITY)

NO. 8/E1/8
THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE

TO CREATE AN ARTIFICIAL GRAVITY EFFECT FOR HUMAN HABITATS AND SPACE PROCESSING

3. NEED ANALYSIS

a) LEVEL NOW [9], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY DATE: [1985]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR
ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [ ]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [X] COMPUTER SIMULATION (Check one or more)

f) R&T BASE CANDIDATE

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY CONTROL OF FLEXIBLE STRUCTURES

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

- CONTROL SYSTEM FOR SPINNING FLEXIBLE VEHICLES.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF ____

TITLE Control of Spinning Spacecraft

NO. 8 / E1 / 8
THEME / W.G. / TASK

DATE 4 / 27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Perform analytical studies and simulations of proposed control systems.
Design of Flight Experiment(s) (Scale Model)
Flight Test Scale Model

7. ALTERNATIVE APPROACHES/OPTIONS

Zero "G" for man in space.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Analysis	▼																			
Simulation		▼																		
Design			▼																	
Integr & C/O				▼																
Flight Test					▼															
MANPOWER (M-Y) INHOUSE	2	2	2	3	4															
MANPOWER (M-Y) CONTRACT																				
FUNDING (10^6 $) INHOUSE																				
FUNDING (10^6 $) CONTRACT	.2	.3	.5	.5	.5															

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF

1. TITLE AUTONOMOUS OPERATIONS AND MISSION MODIFICATION

NO. 1,7,8,10,11,12/E1/11
THEME / W.G. / TASK

DATE 4 /26 / 76

2. OBJECTIVE

EXTEND THE AUTONOMOUS NAVIGATION TECHNOLOGY TO INCLUDE CAPABILITY TO PROVIDE ADAPTIVE ON-BOARD SEQUENCE MODIFICATION TO AUTONOMOUSLY REACT TO RECEIVED SCIENCE DATA

3. NEED ANALYSIS

a) LEVEL NOW [1], WILL BE LEVEL [1] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1990]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [X] MEDIUM [ ] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE 506-19-21 (50K)

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY COMPUTING HARDWARE TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

- DECISION MAKING LOGIC, PARTICULARLY MULTI-LEVEL AND MULTI-STAGE DECISIONS

LEVEL
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

STATE OF ART

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF ____

TITLE Autonomous Operations & Mission Modification

NO. 1,7,8,10,11,12/E1/ 11
THEME / W.G. / TASK

DATE 4/27/76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Study alternate approaches using candidate experiments, bringing the technology to level 5 prior to defining a specific demonstration flight experiment. Detailed laboratory and simulation modeling of mission situations, under varying levels of onboard simulated control.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

506-19-21

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Alt. Approach Study			—	—	—	—	Δ													
Mission Modeling & Simulation					—	—	—	—	—	Δ										
MANPOWER (M-Y)																				
INHOUSE																				
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE			.2	.2	.3	.3	.3	.3	.5	.5										
CONTRACT																				

SPACE TECHNOLOGY NEED **FORM NO. 1**
PAGE 1 OF _____

1. TITLE Low Thrust Guidance and Navigation **NO.** 1,9,10,12/E1/13
THEME / W.G. / TASK
DATE 4 / 28 76

2. OBJECTIVE Develop Low Thrust Guidance and Navigation Systems

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1985]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [ ]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [X] Computer Simulation (Check one or more)

f) R&T BASE CANDIDATE _____

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Low Thrust Engine Technology

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

1. Develop low thrust navigation and guidance analysis techniques.
2. Develop prototype operational navigation software.
3. Develop low thrust compatible orbit determination techniques and control strategies.
4. Develop precision means of controlling engine thrust magnitude and direction.

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED FORM NO. 1
PAGE 2 OF ____

TITLE Low Thrust Guidance and Navigation

NO. 1,9,10,12/E1/13
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Study and select from among a number of promising candidates, the low thrust navigation system of choice. Develop prototype navigation operation software. Ground test engine thrust magnitude and direction control.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

186-67-74 (75K)

9. TECHNOLOGY SCHEDULES

FY / SCHEDULE ITEM	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Nav. System Design			—	—	▼															
Software				—	—	—	▼													
Ground Test						—	—	▼												
MANPOWER (M-Y) INHOUSE			4	6	6	3														
CONTRACT																				
FUNDING (10^6 $) INHOUSE			.3	.5	.5	.4														
CONTRACT																				

SPACE TECHNOLOGY NEED — **FORM NO. 1**

PAGE 1 OF _____

1. TITLE Autonomous Rendezvous and Docking — NO. 7-12 / E1 / 14 (THEME / W.G. / TASK)

DATE 4 / 27 / 76

2. OBJECTIVE
To develop a cooperative rendezvous and docking capability between a "target" vehicle and the rendezvous vehicle.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [2] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1985]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [ ]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [ ] _____ (Check one or more)

f) R&T BASE CANDIDATE _____

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Improve ground operations reaction time to reduce onboard system complexity on initial applications.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED
Program must include development of

(1) Rendezvous navigation system analysis capability; i.e., design, analysis, optimization of rendezvous strategies.

(2) Inter vehicle range, range rate, and angle detection and sensing systems.

(3) Onboard information processing/decision/command structure technologies.

(4) Precision proximity and attitude alignment sensing for final closure and latching.

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

TITLE Autonomous Rendezvous and Docking

NO. 7.12/E-1/14
THEME / W.G. / TASK

DATE 4/27/76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Conduct a program leading from early trade-off studies on hardware and technique alternatives through to a shuttle based demonstration probably with the shuttle playing a passive rôle and a prototype vehicle docking with it.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Study Phase			→	→																
Design/Analysis Tech.				→	→															
Hardware Devel.					→	→														
Demonstration					→	→														
Tech. Read.					→	→	→													
MANPOWER (M-Y) INHOUSE			1.0	1.5	3	3	1													
CONTRACT			2	2	4	4	1													
FUNDING (10^6 $) INHOUSE			.05	.05	.05	.1	.05													
CONTRACT			.3	.5	.7	.7	.2													

SPACE TECHNOLOGY NEED — **FORM NO. 1**

1. TITLE ATTITUDE, FIGURE, AND STABILIZATION CONTROL OF LARGE SPACE STRUCTURES AND ARRAYS

NO. 7.8.9.11/E1/15 (THEME / W.G. / TASK)

DATE 4 / 28 / 76

2. OBJECTIVE
To stabilize and control the attitude of a large flexible structure whose geometry, mass distribution, attitude, and orbit may change while in orbit

3. NEED ANALYSIS

a) LEVEL NOW [1], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY DATE: 1988

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR
ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [X] Computer Simulation (Check one or more)

f) R&T BASE CANDIDATE RTOP 506-19-14, $50K, 506-19-13, $50K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY a. Estimation Filter Development; b. Attitude Control of large-scale flexible structures; c. Hierarchical control theory; d. Stability theory of nonlinear digital control systems; e. High ISP Propulsion; f. Improved motion sensors (i.e. distributed, CCD, etc.)

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

a. Alternate structure and array configuration concepts
b. Adaptive and other appropriate control system techniques
c. Concepts for efficient use of multiple effectors such as CMG's, magnets, energy and momentum storage devices, etc.
d. Figure control system.
e. Figure error sensors such as laser devices
f. Estimation and observer theory and use of distributed sensors and actuators.

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

TITLE ATTITUDE, FIGURE, AND STABILIZATION CONTROL OF LARGE SPACE STRUCTURES

NO 7,8,9,11/E1/15
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

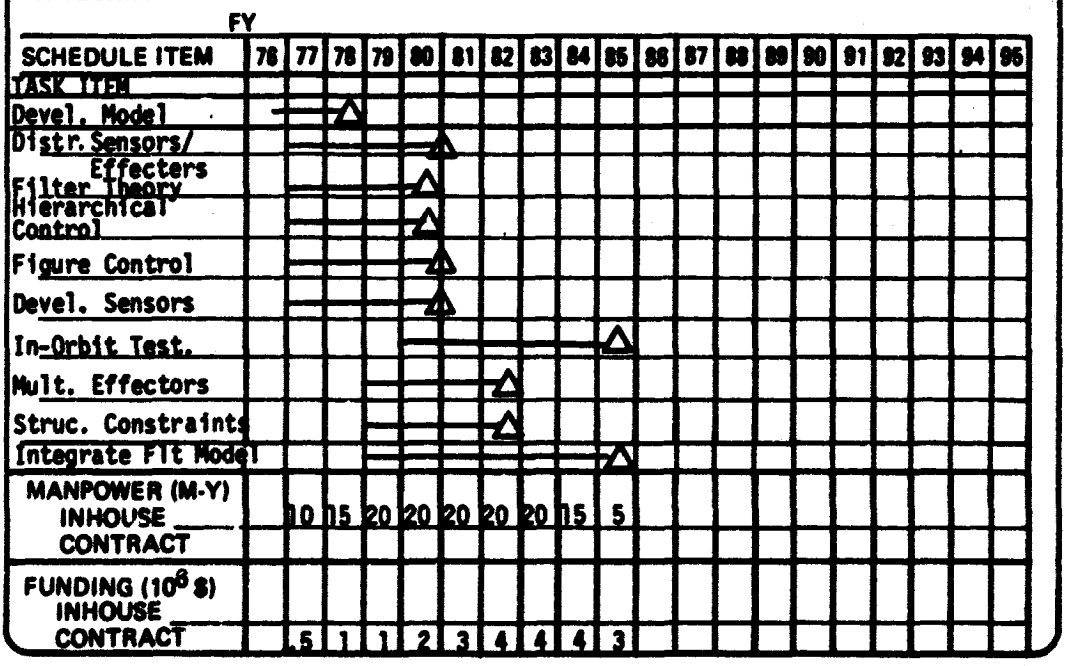
a. Study alternate configuration concepts
b. Develop large-scale high-fidelity model of system to portray dynamics
c. Extend control, estimation, and observer theory as required,
d. Develop hardware (Items 5d, 5e)
e. Develop in-orbit test methods
Develop test model

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

~~506-19-14~~
910-08-01,-02

9. TECHNOLOGY SCHEDULES



SPACE TECHNOLOGY NEED FORM NO. I

1. TITLE Integrated Power and Attitude Control Systems (IPACS) NO. 7, 11 /EI/16 THEME / W.G. / TASK

DATE Apr /26/ 1976

2. OBJECTIVE

To develop the technology required for design and development of combined energy storage and momentum storage fly wheel systems.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY DATE: 1985

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [ ] MEDIUM [X] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [ ] GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X] OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY None

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

- Composite Wheel Development and Testing
- Advanced High Frequency, High Power, Solid State Motor and Generator Electronics
- High Speed Magnetic Bearings

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED FORM NO. 1

TITLE INTEGRATED POWER AND ATTITUDE CONTROL SYSTEMS (IPACS)

NO. 7,11/E1/16 (THEME / W.G. / TASK)

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

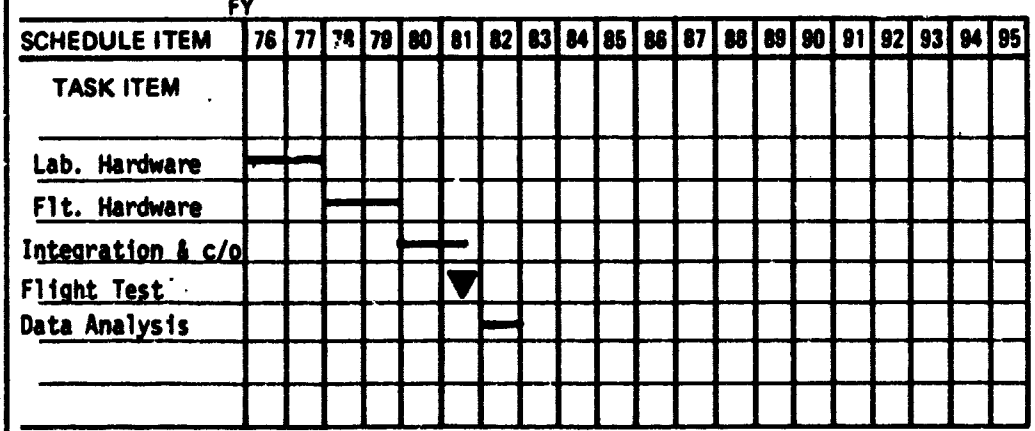
Modify the laboratory spin assemblies for flight test demonstration of zero "G" bearing lubrication and/or magnetic suspension.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

IPACS' RTOP 909-74-35?

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)																				
INHOUSE			2	3	3	2	1													
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE																				
CONTRACT			.20	.50	.50	.20	.10													

SPACE TECHNOLOGY NEED FORM NO. 1

PAGE 1 OF _____

1. TITLE CHECKOUT, SELF TEST, AND REPAIR (STAR) NO. A11 /E-1 /18
THEME / W.G. / TASK

DATE 4 /28 / 76

2. OBJECTIVE
To provide STAR capabilities for GNC systems in order to support ambitious missions with long life term requirements, and to reduce costs, ground support, turnaround time and to prevent massive abort.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1990]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [X] SPACE FLIGHT TEST [X]
OTHER (Specify) [X] Computer Simulation (Check one or more)

f) R&T BASE CANDIDATE 506-19-14 $20K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY
Adaptive software research required for self test and repair of other subsystems.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED
Develop redundant controls configuration
Develop multi-microprocessor arrays
Determine optimum strategy in failure and environmental context.

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED — **FORM NO. 1**
PAGE 2 OF ____

TITLE Checkout Self Test and Repair (STAR)

NO. 10/E-1/18
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

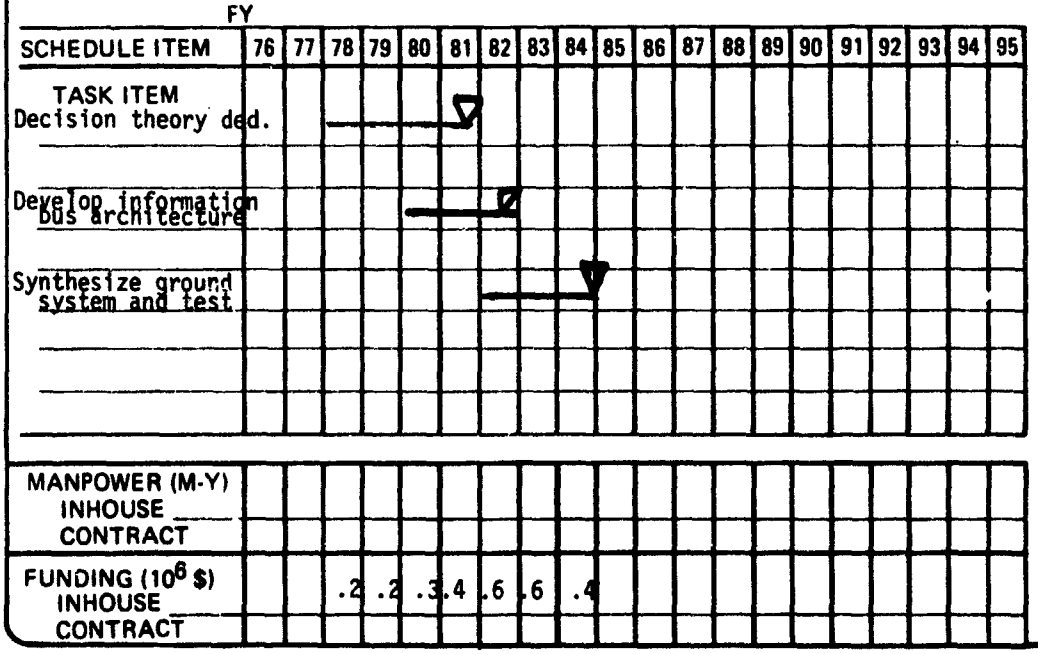
A coordinated, iterated program of technique, hardware, and software development of fault tolerant and redundant guidance and control system for the Planetary Exploration Facility

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

506-19-14

9. TECHNOLOGY SCHEDULES



SPACE TECHNOLOGY NEED **FORM NO. 1**

PAGE 1 OF _____

1. TITLE COMPUTER-AIDED CONTROL SYSTEM DESIGN NO. A11/E1/19
THEME / W.G. / TASK

DATE 4 /28 / 76

2. OBJECTIVE
To enhance the efficiency of computers in design of control systems and simulation of vehicle dynamics.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [4] FOR OPERATIONAL SYSTEM USE BY [DATE: 1984]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [X] Computer Simulation (Check one or more)

f) R&T BASE CANDIDATE RTOP 506-10-13 , $75K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

(a) Extend and improve existing techniques for designing sampled-data (digital) control systems to select control system gains and computer sample periods.

(b) Extend capability to analyze digital control system containing significant nonlinearities in attempt to obviate limit cycle phenomena.

(c) Extend ability to specify quantization of sensed parameters.

(d) Design computer-aided design techniques for optimizing digital controllers and filters.

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED FORM NO. 1

PAGE 2 OF ____

TITLE Computer-Aided Control System Design NO. 1 E1 19

THEME / W.G. / TASK

DATE 4/28/76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

a. Extend techniques for selecting digital control system gains and sample periods.

b. Extend capability to analyze digital control systems containing significant nonlinearities - predict and obviate limit cycles.

c. Extend ability to define quantization levels of sensed parameters.

d. Develop optimization techniques for digital controlled and filter design.

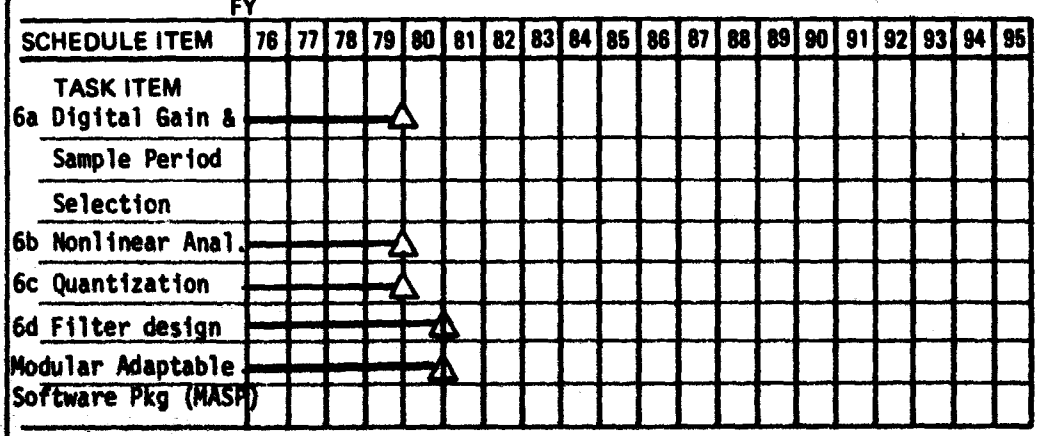
7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

910-08-01, -02

506-19-13

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y) INHOUSE	2	3	4	4	3	2														
CONTRACT																				
FUNDING (10^6 $) INHOUSE	.10	.25	.25	.35	.20															
CONTRACT																				

SPACE TECHNOLOGY NEED FORM NO. 1

PAGE 1 OF _____

1. TITLE Autonomous Terminal Navigation for Planetary Body Approach

NO. 1,10 /E-1/20
THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE
Develop and demonstrate ability to autonomously control flight path and instrument pointing relative to a target.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY DATE: 1990

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [ ]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [ ] _____ (Check one or more)

f) R&T BASE CANDIDATE 506-19-21 (500K)

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY None

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Develop flight sensor and processing capability for the precision detection and center finding of the planetary body relative to a star field.
Develop on-board information processing/decision/command structure technologies.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

ORIGINAL PAGE IS
OF POOR QUALITY

SPACE TECHNOLOGY NEED FORM NO. 1
PAGE 2 OF ____

TITLE Autonomous Terminal Navigation for Planetary Body Approach

NO. 1.10 /E-1/20
THEME / W.G. / TASK

DATE 4 /27 /76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Extend current R&T program to include a flight/ground demonstration of a system to autonomously deliver a spacecraft and point its instruments to a target planet, satellite, astroid, or comet. Test on JO '81 or other suitable mission.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

RTOP 506-19-21 (500K)

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Flt. H/W Dev.				——	Δ															
Ground Computer				▲																
Grnd S/W Devel.				——	——	——	Δ													
Lunar Test						Δ														
Jupiter Test								——	Δ											
Technology Read.									▲											
MANPOWER (M-Y) INHOUSE																				
CONTRACT																				
FUNDING (10^6 $) INHOUSE			.5	1.3	1.6	.9	.7	.1	.3											
CONTRACT																				

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF _____

1. TITLE Extended Life Attitude Control Systems (ELACS)

NO. 1.7-11/E1/21
THEME / W.G. / TASK

DATE 4 / 27 / 76

2. OBJECTIVE To develop the technology and demonstrate an attitude control system capable of long life through fault tolerance and applicable to a wide range of unmanned, earth orbital, and planetary programs.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY DATE: 1984

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [ ]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] _____ (Check one or more)

f) R&T BASE CANDIDATE RTOP 506-19-14 FY 78 NOA $450K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Microprocessor technology, CCD technology Magnetic bearing, digital system technology 506-19-14 (450K)

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

1. To provide the system design for interfacing sensors, computers, and actuators and providing the redundancy and expendable management with simplicity of cross-strapping and incremental add-on capability.
2. Develop the control analysis tools to deal with flexible vehicle effects.
3. To develop a fault tolerant programmable attitude controller with fault detection and correction capability.
4. Development of a magnetic bearing reaction wheel.
5. To develop a microprocessor-controlled CCD star tracker.
6. Radiation hardening of components and electronics.

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. I
PAGE 2 OF ____

TITLE Extended Life Attitude Control Systems

NO. 7-11/E1/21
THEME / W.G. / TASK

DATE 04 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

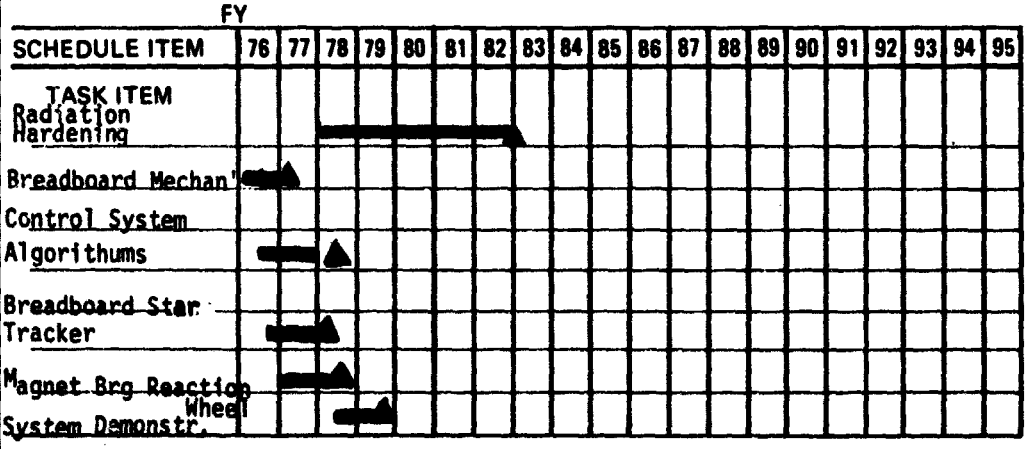
A program to develop the system concept and relevent elements of technology in sensors, actuator and control processors including related system and analysis tasks leading to a laboratory demonstration of the techniques

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

506-19-14(ELACS)

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)																				
INHOUSE		7	9	8	6	6	6	6												
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE		.45	.75	.75	.5	.5	.5	.5												
CONTRACT																				

SPACE TECHNOLOGY NEED **FORM NO. 1**

PAGE 1 OF _____

1. TITLE ROBOTICS AND TELEOPERATORS FOR SPACECRAFT ASSEMBLY, MAINTENANCE AND REPAIR

NO. 1,7,8,9,11/E-1/23
THEME / W.G. / TASK

DATE 4 / 27 / 76

2. OBJECTIVE
DEVELOP A GENERAL CLASS OF ROBOTIC DEVICES WITH SUFFICIENT DEXTERITY TO PERMIT MECHANICAL OPERATIONS IN SPACE.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1987]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [X] MEDIUM [ ] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ] DEPENDING ON APPLICATION

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [X] COMPUTER SIMULATION (Check one or more)

f) R&T BASE CANDIDATE YES 506-19-32 (250K)

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY ADVANCED SOFTWARE SYSTEMS, HIGH CAPACITY ENERGY STORAGE, ARTICULATE MANIPULATORS, LOW THRUST PROPULSION.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

(1) SCENE AND IMAGE ANALYSIS PROCESSOR
(2) ROBOTIC EYE/HAND COORDINATION
(3) NAVIGATION IN CONFINED SPACE
(4) RADIATION HARDENING (FOR SOME APPLICATIONS)

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED — **FORM NO. 1**

PAGE 2 OF ____

TITLE Robotics and Teleoperators for Spacecraft Assembly, Maintainance and Repair

NO. 1,7,8,9,11 /EI/23 — THEME / W.G. / TASK

DATE 04 /27 /76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

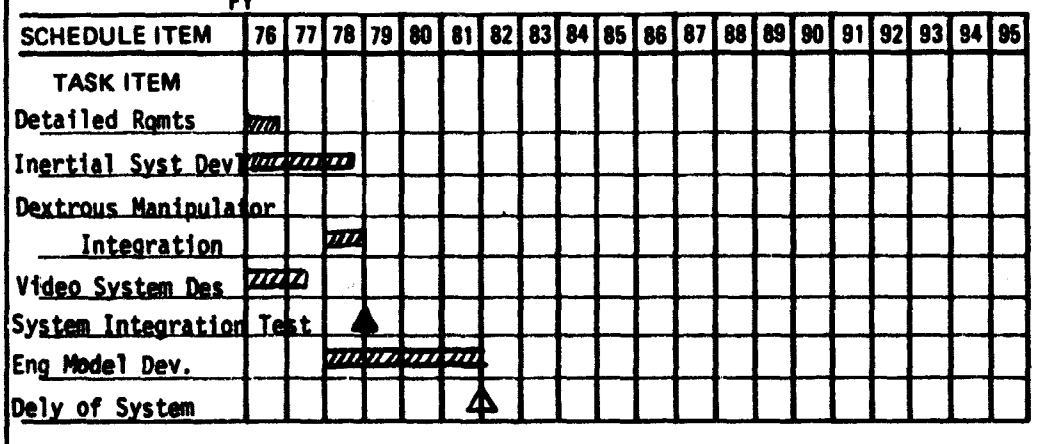
Increase current teleoperator and robotics development program to include dexterous manipulator systems, image processing/video link systems, and inertial stabilization as appropriate for free flying teleoperators.

7. ALTERNATIVE APPROACHES/OPTIONS Use astronauts

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Robotics/Teleoperator development at JPL RTOP 186-68-55 GCC Technology, 506-19-32

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)																				
INHOUSE	10	10	15	15	15	15														
CONTRACT	10	10	15	15	15	15														
FUNDING (10^6 $)																				
INHOUSE	.5	.5	.75	.75	.75	.75														
CONTRACT	.5	.5	.75	.75	.75	.75														

SPACE TECHNOLOGY NEED FORM NO. 1

PAGE 1 OF _____

1. TITLE Advanced GN&C Components for the STS Systems

NO. 1,12/E-1/26
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE Improve performance, operational costs, reliability, and operating life of future STS systems.

3. NEED ANALYSIS

a) LEVEL NOW [5], WILL BE LEVEL [7] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1985]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [ ]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [X] Hardware Development (Check one or more)

f) R&T BASE CANDIDATE 506-19-14 (50K), 505-25-07 (105K)

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY CCD technology, power electronics, general electronic technologies

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Advanced systems will require the demonstration of electromechanical speed control for flight control systems, the application of new sensor elements to inertial reference units, and star trackers, and new rendevous sensors to replace conventional radar. Technology advances in onboard data processing system architecture will be required to insure the optimum processing configuration consistant with GN&C requirements. Such architectures may involve hierarchies of microprocessors for subsystem level processing.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED **FORM NO. 1**

TITLE Advanced GN&C Components for the STS System

NO. 1.12/E-1/26
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

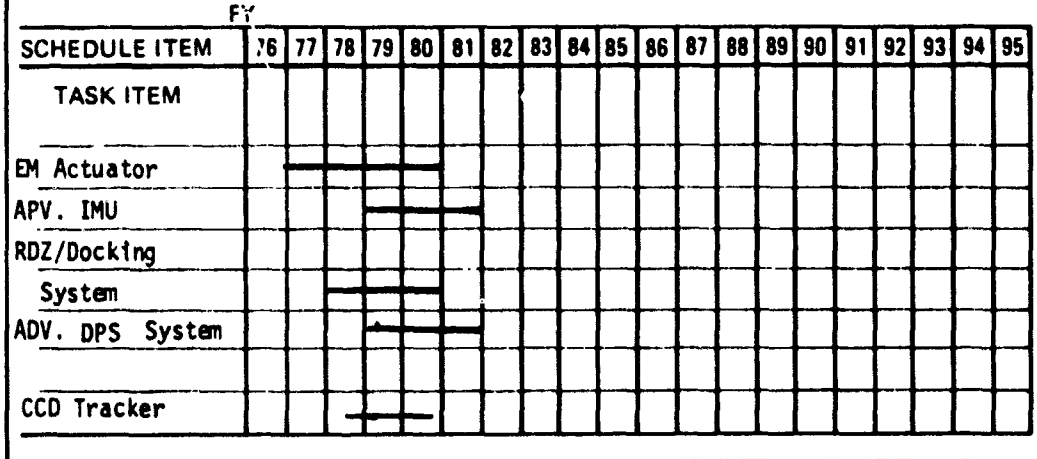
The basic technology is now being developed but needs to be integrated at the subsystem level. The basic approach would be to select the technology to be introduced (lasers, CCDs, etc.) and to enter into a separate technology development program for each component at the component/subsystem level.

7. ALTERNATIVE APPROACHES/OPTIONS Continue to use obsolete technologies.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

MSFC Laser Gyro Program; JSC Electromechanical Actuator program. JSC Advanced Orbiter/System Concept Studies. Ames/JPL VIP tracker development: JPL RTOP 506-19-14, CCD Tracker Dev.

9. TECHNOLOGY SCHEDULES



MANPOWER (M-Y)																				
INHOUSE		1	6	7	5	3														
CONTRACT		2	5	7	7	3														
FUNDING (10^6 $)																				
INHOUSE		.1	.3	.4	.3	.1														
CONTRACT		.2	.5	1.5	3.	1														

SPACE TECHNOLOGY NEED **FORM NO. 1**

PAGE 1 OF _____

1. TITLE Dynamics and Control of Manned Aerospace Vehicles

NO. 12 E1 27
THEME / W.G. / TASK

DATE 4 / 27 / 76

2. OBJECTIVE
To improve the flying qualities of manned aerospace vehicles

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [7] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1983]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [XX]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [XX] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [XX] RESEARCH [XX]
GRD TEST [ ] AIR CRAFT TEST [XX] SPACE FLIGHT TEST [XX]
OTHER (Specify) [ ] _____ (Check one or more)

f) R&T BASE CANDIDATE _____

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Hi Speed aerodynamics; aerothermodynamics; onboard command processing; in-situ sensing.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED
Active control technology and handling quality advancements in lifting body reentry vehicles.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED FORM NO. 1
PAGE 2 OF ____

TITLE Dynamics and Control of Manned Aerospace Vehicles

NO. 12 E1 27
THEME / W.G. / TASK

DATE 4 / 27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Analysis of control configured vehicle concepts to advanced shuttle configuration. Advanced control theory concepts and command processing techniques to improve the control of the vehicle dynamics in manual and automatic modes.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM Advanced Orb. Concepts	—	—	—																	
Control Analysis			—	—																
S/W Development				—	—															
FTt. Test Development						—	—													
MANPOWER (M-Y) INHOUSE	.5	.5	1	1	2	1	1													
CONTRACT	1	1	3	3	2	2	1													
FUNDING (10^6 $) INHOUSE	.1	.1	.1	.1	.1	.1	.1													
CONTRACT	.1	.1	.3	.3	.2	.2	.1													

SPACE TECHNOLOGY NEED **FORM NO. I**

PAGE 1 OF _____

1. TITLE Differential Very Long Baseline Navigation Technology (ΔVLBI)

NO. 1,10 / E1 / 28
THEME / W.G. / TASK

DATE 4 /28 / 76

2. OBJECTIVE

Create a VLBI measurement and measurement processing system capable of low cost, highly precise (10^{-8} radian Earth relative) navigation anywhere within the solar system

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1985]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [ ]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [ ] _____ (Check one or more)

f) R&T BASE CANDIDATE $1500K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY OTDA sponsored ground systems development

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Create the Design and Analysis Base capable of analyzing measurement accuracy and acquisition requirements.

Create prototype measurement calibration and processing software.

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED — **FORM NO. I** — PAGE 2 OF ____

TITLE Differential Very Long Baseline Navigation Technology (ΔVLBI)

NO. 1,10 / E-1 / 28 (THEME / W.G. / TASK)

DATE 4 /28 /76

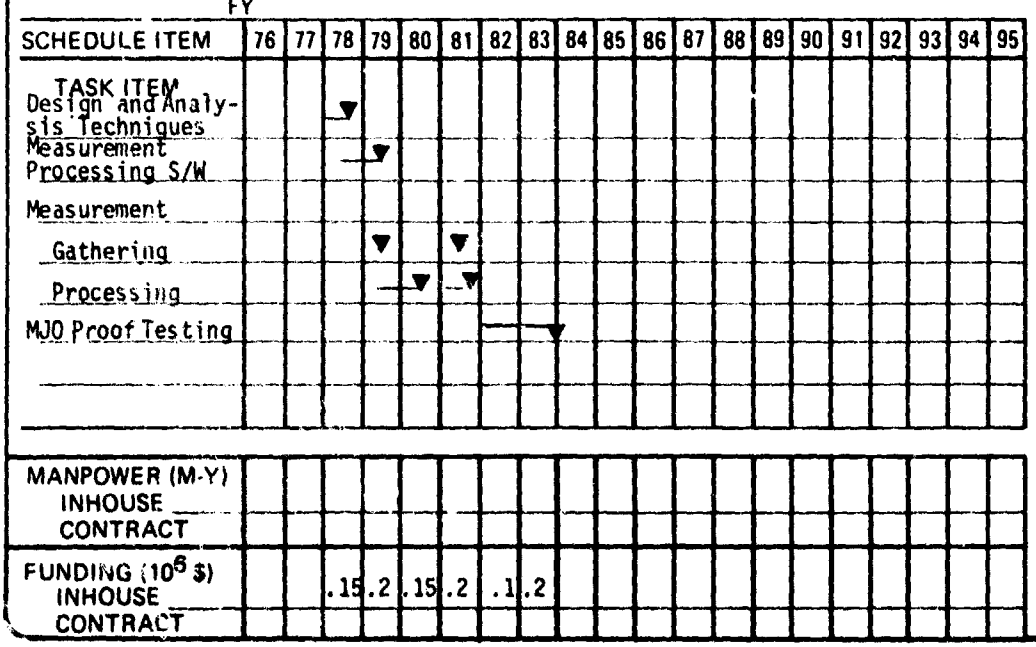
6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

A program, cooperating with OTDA ground system development, of requirements analysis, data base gathering, processing and flight demonstration employing the MJS encounters is required.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES



SPACE TECHNOLOGY NEED PRIORITY ASSESSMENT

FORM II
FORM III

(List in numerical order, 1 – Highest Priority)

WORKING GROUP E1 NGC

DATE 4 / 29 / 1520

	THEME NO. / TECHNOLOGY NEED NO.	7 SPACE POWER	8 SPACE INDUST.	9 SETI	10 SOLAR SYS. EXPL.	11 GLOBAL SERVICE	12 ADV.TRANS. SYS.	NASA R&T		SUMMARY PRIORITY ASSESSMENT			
								Current	R&T Base	WG	TT	R&T Base	'78 Total
1.	Autonomous Guidance & Control of Launch Vehicles						5			17		K$	K$
2.	Roving Vehicles & Sample Selection		7		8			X	9	15		930	3,000
3.	Precision Pointing of Spacecraft & Instruments at inertial targets	2	4	1				X	2	3		275	3,000
4.	Precision Pointing & Tracking Systems for non-inertial targets	3			2	1		X	1	2		550	1,000
5.	Autonomous Navigation for Earth Orbiters	12				5	4			8			
6.	Dynamics & Control of Unmanned Entry & Landing				7		1			9			
7.	Automatic Station-keeping	8	3	3	12					10			
8.	Control of Large Spinning Spacecraft		5							21			
9.	Deleted												
10.	Deleted												
11.	Autonomous Operations & Mission Modification	10	8		1	2	6	X	5	4		50	200
12.	Deleted												
13.	Low Thrust Guidance & Navigation			5	3		8	0	10	13		0	300

SPACE TECHNOLOGY NEED PRIORITY ASSESSMENT

FORM II
FORM III

(List in numerical order, 1 — Highest Priority)

WORKING GROUP EI NGC

DATE 4 / 29 / 1520

	THEME NO. / TECHNOLOGY NEED NO.	7 SPACE POWER	8 SPACE INDUST.	9 SETI	10 SOLAR SYS. EXPL.	11 GLOBAL SERVICE	12 ADV.TRANS. SYS.	NASA R&T		SUMMARY PRIORITY ASSESSMENT			
								Current	R&T Base	WG	TT	R&T Base	'78 Total
14.	Autonomous Rendezvous & Docking	9	6	3	6	8	2			5		K$	K$
15.	Attitude, Figure, and Stabilization Control of Large Space Structures	1	1	2		3		X		1		100	1,000
16.	Integrated Power & Attitude Control Sys.	4				9				16			
17.	Deleted												
18.	Checkout, Self-Test, & Repair (STAR)	7	9	7	9	7	7	X	8	11		20	200
19.	Computer-aided Control System Design	11	10	6	10	10		X	4	12		75	425
20.	Autonomous Terminal Navigation for Planetary Body Approach				5			X	6	14		500	1,300
21.	Extended Life Attitude Control System	5	11	4	4	6		X	3	7		450	750
22.	Deleted												
23.	Robotics & Teleoperators for Spacecraft Assembly & Maint.	6	2	9		4		X	7	6		200	1,500
24.	Deleted												
25.	Deleted												
26.	Advanced GN&C Components for Advanced Shuttle						9	X	11	18		300	700

SPACE TECHNOLOGY NEED PRIORITY ASSESSMENT

FORM II
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	THEME NO. / TECHNOLOGY NEED NO.	7 SPACE POWER	8 SPACE INDUST.	9 SETI	10 SOLAR SYS. EXPL.	11 GLOBAL SERVICE	12 ADV.TRANS. SYS.	NASA R&T		SUMMARY PRIORITY ASSESSMENT			
								Current	R&T Base	WG	TT	R&T Base	'78 Total
27.	Dynamics & Control of Manned Aerospace Veh.						3			19		K$	K$
28.	Differential Very Long Base Interferometry Navigation				11			0	12	20		0	150